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EMOTIO – Design of a Toolkit Enabling User Innovation

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Abstract

In the face of increasing product commoditization and intense international competition, companies in high-wage countries must produce high quality products designed to match customer demands perfectly.
To improve the customer-product-fit research in the area of Interactive Value Creation has focused on integrating customers into the product development process. After providing an overview of the previous research in the areas of interactive value creation and User Toolkits, this paper this paper presents the design of an Embedded User Toolkit and a preliminary field study conducted using a prototypical toolkit implementation. Finally the results of this study which will serve to guide future research are presented.

Keywords: Interactive Value Creation, User Innovation, User Toolkit, Product Development, Quality Management

1. Introduction

Customers only decide to purchase products they believe match their needs and expectations. Expectations are in turn based on preformulated demands and requirements, which are translated into product specifications by companies.
A company's success is largely dependent upon whether customers feel that their needs are being met by the offered products. A large overlap between customer requirements and perceived product characteristics leads to a higher probability of a sale and a greater willingness on the side of the customer to pay a higher price. Its achievement is difficult due to constantly evolving customer requirements and the difficulty to determine these requirements. Often new demands arise during product usage, while others, initially perceived as highly relevant, become less important [1]. The recent trend towards an increasing degree of product individualization and the resulting heterogeneous customer expectations exacerbate the achievement of a high degree of overlap between market demands and product characteristics.

The superordinate research question which arises from this issue is how companies are able to design products which best meet the requirements of the customers. Established approaches can be found in the research area of Interactive Value Creation, which investigates the integration of customers in the product life cycle as active partners.

This paper introduces the concept of an Embedded User Toolkit as a new concept of Interactive Value Creation. The main purpose of a Embedded User Toolkit is to give companies access to customers' requirements by giving customers the tools to adapt products to their individual needs. Therefore an Embedded User Toolkit in the end benefits both the company and the customer. This paper is focused on the design of a toolkit and its field trial in a preliminary study. The primary goals of this study were to assess the accceptance of an Embedded User Toolkit and to gain information to guide future research and implementation in this area.

2. EMOTIO – Customer Integration into Product Development

This section first provides a brief overview of approaches in the research area Interactive Value Creation and the established concept of User Toolkits. Subsequently the Embedded User Toolkits and the EMOTIO research project are introduced. Finally the types of innovation which can be generated by Embedded User Toolkits are discussed.*Interactive Value Creation*

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In recent years the difficulties to determine customers' requirements have led to research regarding the possibilities of integrating customers into the product development process directly. This research area is referred to as Interactive Value Creation. The terms "customer" and "user" will henceforth be used synonymously.

The idea underlying Interactive Value Creation is to no longer view customers as passive recipients of a company's value creation but to integrate them into the value creation process as active partners. This activation of the customer transforms conventional value creation into Interactive Value Creation [2]. A basic concept is the division of labor between the company and the customer which enables the usage of specialized knowledge in completing a product design.

The research field contains a variety of different approaches such as Open Innovation, Mass Customization or Open Source.

Open Innovation is an approach to integrate the customer into the process of innovation, i.e. early phases of the product development process. Later phases are not directly impacted. Participating users can develop their solutions in an open solution space. Solutions are often developed in interdisciplinary, heterogeneous groups, which often lead to fresh perspectives and scientific approaches being introduced to into development which would not have been included in an internal company effort [3].

Mass Customization aims to combine the advantages of products customized to the individual customer needs with a production efficiency comparable to that of mass production [4,5]. To achieve the goal of low costs, a highly efficient value creation chain is required. To keep costs to a minimum external participants are integrated only into the final steps of the product development process.

The Open Source principle is an established form of Interactive Value Creation in the software industry. It aims for the voluntary integration of external parties by allowing for the contribution of ideas and participation in both the conception of the product architecture and its subsequent implementation.

EMOTIOs position in the area Interactive Value Creation and its relationship with these established approaches is discussed in [6] in detail and lies outside of the scope of this publication.

2.2. User Toolkits for Innovation

An early example of User Toolkit use can be found in the semiconductor industry of the 1980s, where a small startup named LSI Logic first distributed a toolkit consisting of design tools and a library of commonly used design elements to its customers. This measure helped to reduce the number of iterations necessary to produce an application-specific integrated circuit and soon the use of toolkits became widespread for the design of application-specific integrated circuits [7].

The main goal of User Toolkits is to give companies better access to information regarding customers' needs by allowing customers to actively articulate their requirements [8].

According to [8] User Toolkits must satisfy five demands:

1. Appropriate solution space – toolkits should offer users an appropriate solution space within which they can experiment and design solutions tailored to their individual requirements. However during toolkit design, the limits of the targeted production systems must be taken into consideration.
2. Learning by doing with trial-and-error – toolkits must show users the results of their design decisions and provide feedback concerning design errors. This allows users to proceed through multiple iterations in which the product design is continuously adapted prior to manufacturing.
3. User friendliness – toolkits must be easy to use for the target audience so as to encourage their widespread use.
4. Library of common components – given that the design solutions of users often consist of a customized combination of several common components, toolkits should offer users a library of these common base components to increase development ease.
5. Translatable into production system language – it is essential that the results created using a toolkit can be translated into a set of instructions for a manufacturing system without errors.

An example of toolkits being used in conjunction with Mass Customization is the customization process associated with purchasing cars or computers directly from the manufacturer online. In this example, as is often the case in industrial practice, however both the requirement for an appropriate solution space and the availability of a full trial-and-error cycle are not fulfilled.

2.3. EMOTIO - Embedded Toolkits for User Innovation and Co-Design

The EMOTIO research project seeks to combine aspects from established approaches to Interactive Value Creation and extend the concept of User Toolkits. The goal is to integrate users into product development by allowing them to modify products they have purchased during usage. To this end four areas of research have been defined:

1. Definition of the solution space
2. Acquisition of data on customer activities

3. Analysis of acquired Data
4. Lifecycle oriented integration of customer innovations

Central to a successful implementation is an appropriately designed suitable solution space within which the users can innovate by creating new or recombining existing functionality directly in the product when they become aware of an unfulfilled requirement. All user driven product modifications are recorded by the Embedded Toolkit and relayed for analysis. These can then be analysed and subsequently be fed back along the product lifecycle and thus be used to improve both current and prospective product generations [6]. Thus from a short-term perspective, Embedded Toolkit helps to improve the usability and quality of a product which has already been delivered. From a longer-term perspective, Embedded Toolkit assists companies in developing innovative products based on ideas and input from the targeted market. The the first two of these are reflected in the design of an User Toolkit which is can be integrated into products during production and are thus focus of this paper.

2.4. Types of Innovation

The literature describes many different types of innovation, e.g. incremental, radical, evolutionary, revolutionary, product and process innovation. In order to better understand the idea underlying EMOTIO it is necessary to discuss in which degree a User Toolkit can generate to innovation.

Incremental or evolutionary innovation is defined as an improvement of an existing product in a way that yields price or performance enhancements [9]. In contrast, radical innovation is associated with new product designs and generally does not fit with existing products [10]. Furthermore the evolutionary innovation strongly depends on customer insight capabilities and focuses on orientation towards today's customers whereas the revolutionary innovation focuses on orientation towards tomorrow's customers [11].

Since User Toolkits are embedded into existing products and provide users with the means to recombine existing basic product functionalities the generated innovations are expected to be incremental or evolutionary rather than revolutionary product innovations.

The use of Embedded User Toolkits, subsequent data analysis and information feedback could be seen as a process innovation in itself due to the expected improvements to product development efficiency and effectiveness.

3. Toolkit Design and Implementation

This section focuses on the conceptual design and prototypical implementation of an Embedded Toolkit for User Innovation. Since the research team chose the smartphone as the pilot product for an implementation, the examples in this section were chosen accordingly. Reasons for this choice lie in the preexisting infrastructure for information feedback, high feature density and device availability. For additional information please refer to [7].

3.1. Conceptual Toolkit Design

On a high conceptual level, the toolkit design aims to supply users with a scripting environment based on the event driven programming paradigm. The program code is thus comprised of blocks of executable code, hence referred to as Scripts, which are triggered by a set of Events resulting in a nonlinear flow of execution.

Scripts are a collection of sequentially executed Statements which are mapped to actions, a device is capable of performing. Possible Statements for a Toolkit in a smartphone would be "send short message" or "set ringtone". Events can either be triggered by user interaction, other external sources or internal machine states. The Toolkit allows users to define events and thus also to determine the set of preconditions triggering events. An example of a precondition is "distance to office is less than 1 kilometer". Thus, whenever the device is moved into a radius of less than 1000 meters from the defined location "office", the Event is triggered which in turn leads to the execution of all attached Scripts.

In the Toolkit preconditions of Events are checked by evaluating available information. Information is generated by processing standardized data. During this step data is enriched with semantic meaning by information processing modules. An example of a transformation from data to information is the calculation of "distance from location" using the coordinates generated by a GPS module. Information can in turn be processed and converted to meta-information in any number of steps.

Standardized data is created by converting all raw data provided by data sources to a standardized format. This ensures that information processing modules can rely on inputs of a well defined format and can thus correctly process data from any local and remote sources. An example of standardization would be the expression of temperatures in "degrees Celsius" and their storage as signed 16 bit floating point values.

Data sources of Toolkits can be local or remote. Local sources are either physical components, such as sensors integrated directly into the device, or virtual

detectors of machine states. In a smartphone, examples of local physical sources are GPS, light sensors or gyroscopes. A local virtual source could be an internal "missed call counter". Remote sources are all data sources, which are mapped into the Toolkit but are supplied via a network. Internet resources, such as social networks or sites providing news, fall under this category.

Aside from the Toolkit components, which focus on providing an open solution space for users, a usage profiling component of the Toolkit records product usage patterns and user actions within the solution space. Examples of general information concerning the usage patterns in a smartphone are the number and duration of calls.

3.2. Prototypical Implementation

The Android operating system offers interfaces for applications to make use of many local data sources and to initiate a large number of possible phone actions. This allowed for the development of the toolkit as an application that can be installed after purchase of the product. Research revealed that a preexisting application, Tasker [12], offered many of the aforementioned functionalities of an Embedded Toolkit. Tasker's emphasis lies on the connection of Events generated by local data sources with user created scripts.

The EMOTIO team created an additional application to upload the Tasker data to a server for further analysis. The acceptance of this new created application shall be identified in preliminary studies.

4. Preliminary Field Study

This section provides information on the preliminary field study conducted using the prototypical toolkit implementation introduced in Section 3.2. Initially the purpose and the setup of the study are outlined. The study results are then presented and discussed in the following sections.

4.1. Purpose and Setup

An initial field study with the initial prototype was conducted to ascertain the aspects most critical to design an Embedded Toolkit. More specifically, the following key questions were addressed:

1. What are reasons for not using the Embedded Toolkit?
2. What are the main problems with the prototypical toolkit reported by active toolkit users?
3. From where did users derive their inspiration?

Regarding question one is important to understand the reasons causing customers not to use the prototype application because it helps in identifying the most promising potentials for increasing the acceptance of non-users.

The identification of problems reported by active toolkit users is also instrumental in improving user acceptance. Determining the implications of reported problems is also of importance: while some problems with the offered functionality can actually prevent users from implementing a specific idea, others might only lead to increased implementation time and effort.

By knowing the sources of inspiration, it is possible to decide by which means the creative process can best be supported.

Participants were recruited using flyers and postings on black boards inside and outside of a German university. In all postings, the study was described as an app usage study in which each participant would receive a randomly selected app.

Prospective participants were presented with a suitable consent form which accurately described the data transmitted by the toolkit. This was necessary due to the fact that transmitted data depended heavily on participants' toolkit usage, and could, theoretically be used to create movement profiles or transmit sensitive information such as phone numbers from the user's address book. To address potential privacy concerns, assist in the toolkit software setup and pay each participant a compensation of 10€ all participants were invited to kick-off sessions.

During the kick-off meeting, each participant filled in a general questionnaire about demographical data, technical expertise and smartphone usage behavior.

At the end of the study, all participants were sent a second questionnaire focusing on their toolkit usage. Additionally interviews were conducted with two highly active users, identified directly by analyzing the transmitted toolkit usage data. The study's duration was two months, after which participants could continue to use the application.

Overall, 35 users participated in the study, out of which 31 were men and 4 women. 31 of the 35 participants indicated that their courses of studies had a strong technical focus. The average age was 25 years. On average the participants were familiar with using with mobile phones for 9,4 years, while their average duration of Android smartphone use was 9 months. 24 participants filled in the second questionnaire at the end of the study.

4.2. Initial Field Study – Results

To estimate the acceptance rate of the toolkit application, the most important metrics were the numbers of users that were actually using the prototype and those who were satisfied with it. Automatically

transmitted data containing (manual) modifications of toolkit configurations and (automatic) triggering of Events, showed application activity on seven users' smartphones during the last three days of our study, while the last reported activity from the other 27 users was received more than one week before the end of the study. From seven participants data was only received on the first day of the study. The questionnaire results also show that seven users actively used the application throughout the study. Figure 1 shows the number of users actively using the toolkit plotted over the number of days since the beginning of the study.

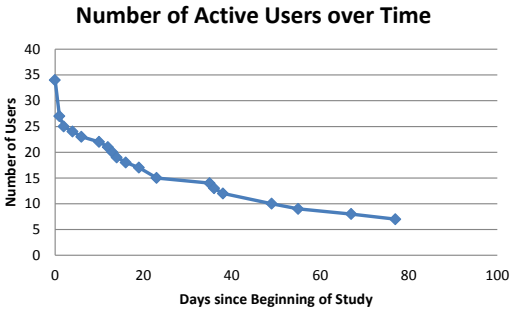

Figure 1: Number of Active Users over Time.

To each of the following questions, six or seven users (of 24 who filled in the questionnaire) replied with yes:

- Would you buy the application if you didn't already have it? (6)
- Would you recommend the application? (7)
- Would you describe yourself as an active user of the application? (6)

Additionally the statement "The application created an additional value to my smartphone by extending its functionality" had seven users who replied with 4 or 5 on a 5 point Likert scale.

The free text answers to the question of why the application wasn't used more frequently (if it wasn't used regularly) can roughly be divided into three categories:

- I don't know of any useful possibilities (5 replies)
- I don't know any additional useful possibilities besides those I already use (4 replies)
- Usability problems (5 replies)
- I could not use the application because the phone was stolen or too old/slow (2 replies).

While the basic concept described in Section 3.2 was well understood (avg. of 3.66, mode 4 on 5 point Likert scale) participants reported usability problems in the following 5 point Likert scale questions:

- Handling of the application is cumbersome (avg. of 3.65, mode 4)
- Setup of configurations is cumbersome (avg. of 3.83, mode 4)
- Testing of functionality is cumbersome (avg. of 3.78, mode 4).

Figure 3 shows the distribution of answers to the aforementioned questions regarding usability.

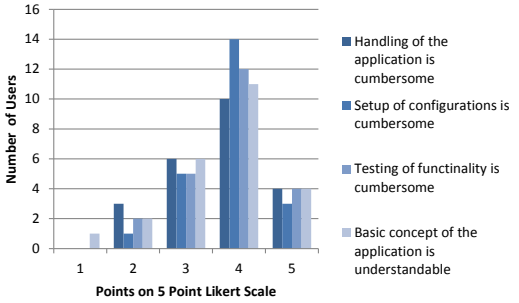

Figure 2: Distribution of Answers Concerning Usability

To find out from where participants derived their inspiration when they had an idea for a modification, a question was added to address this. The options chosen most frequently were:

- While interacting with the application (10)
- From examples taken from the internet (8)
- I had the idea before using the application (7)
- From discussions with friends and other acquaintances (5).

4.3. Initial Field Study – Discussion

Approximately 20% of participants actively used the application during the study. Taking into account that the participants reported usability issues, it is probable that more than 20% have an interest in the general idea of a toolkit application on their smartphone. From detailed interviews with two highly active participants we learned that especially the first steps in using the toolkit proved difficult and discouraging. They proposed offering examples of modifications made within the toolkit and creating a platform allowing for the exchange of modifications among participants.

In light of the results from the questionnaire and the interviews, it seems likely that a significantly larger percentage of smartphone users would be interested in an Embedded Toolkit if the effort required to use it, especially in the beginning, were sufficiently low. This resonates with von Hippel's requirement of user friendliness (refer to Section 2.2).

The widespread sources of inspiration for created modifications lead the authors of this paper to the following conclusions:

1. Future versions of the toolkit will include a sharing function for user modifications. The possibility to browse modifications created by other users will presumably significantly increase the value of the application to most users.

2. A large number of preexisting Events and Statements is important to support the creativity of users, since many users were inspired while interacting with the application and exploring its capabilities. Incorporating a multitude of features is a significant challenge to User Interface (UI) design, which is exacerbated by smartphones' display size. Several participants of the study remarked that the large number of features lead to problems when searching for specific ones.
3. An online community for active toolkit users could help users to create new ideas through discussions. Furthermore it helps users to transform complex ideas into modifications, when a single user does not possess the knowledge or skill to realize all necessary modifications.

Both the results of the questionnaire and the two interviews conducted with highly active users stressed the problem of insufficient support for modification testing: Testing complex constructs was often highly time-intensive. This precluded the creation of more complex modifications within the toolkit. Thus there is a demand for simulation and testing functionality. These results resonate with von Hippel's requirement of facilities for trial-and-error development [8]. Furthermore less than ideal usability of the prototypical toolkit served to deter users from actively using it.

5. Conclusion

Maintaining a large overlap between customer requirements and product characteristics over the course of a product's lifecycle is instrumental to ensuring customer satisfaction. This is however difficult due to the insufficient knowledge of the company about their customers' needs. Furthermore there is a disparity between requirements articulated prior to product usage and those present in the usage phase, as well as the shifting and development of customer requirements during product usage.

Building upon approaches from the research area of Interactive Value Creation EMOTIO addresses this issue by integrating customers into the company's process of product creation over the course of the entire product lifecycle.

The focus of this paper was the prototypical implementation of an Embedded Toolkit component. A preliminary field study was conducted concerning the two research purposes of identifying the acceptance rate of the toolkit and gaining improvement measurements for the future research. Study results indicate that additional work in the toolkit area should focus on improving the User Interface, providing users with a platform on which to share their modifications and enhancing testing and debugging facilities.

A forthcoming paper will discuss the results of a second field study conducted with a version of the Embedded User Toolkit refined in accordance with the results of the preliminary study presented in this paper.

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